Derivation of Topographic maps from Laser Scanning Data

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Introduction

Applications' demands are made about:

More maps

Quality (better maps)

Currency (up-to-date maps)

Accuracy (precise maps)

Cost (Cheaper maps)

Variety (different maps)

New map production's technologies

The role of cartographic knowledge as applied to map production:

Map design

Symbolization

Text and label placement

Generalization

Color selection

…….

Introduction

Maps can be grouped in three categories:

- Cadastral maps, city maps and technical planes
- **Topographic maps**: showing the ground surface with its features and objects, such as rivers, buildings, vegetation and roads….. etc. Topographic maps have scale between about 1:25000 and 1:100000.
- Geographic maps and thematic maps.

(Kraus, 1995)

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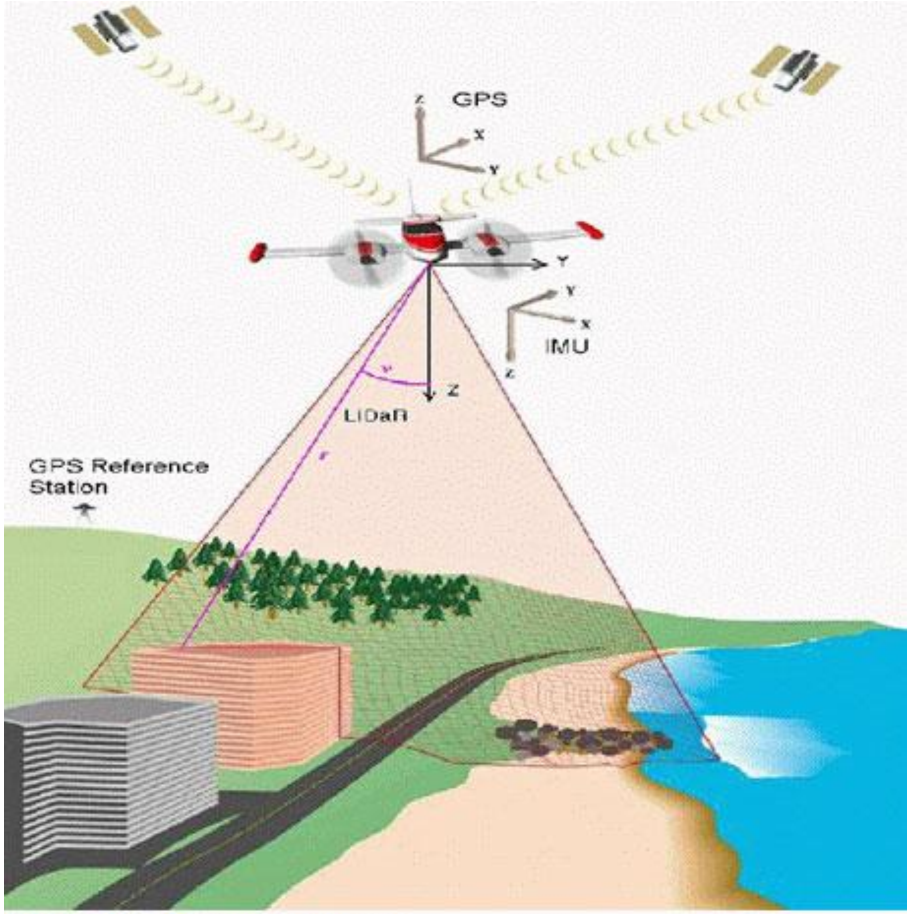
Introduction

Topographic data acquisition technologies:

- **Traditional methods**
  - Theodolite, Total station .....
- **Photogrammetry**
  - Close range
  - Aerial
  - Satellite
- **Laser Scanning**
  - Terrestrial
  - Airborne
  - Space
- **Interferommetry (RADAR)**
  - INSAR (Synthetic Aperture RADAR)

Airborne Laser Scanning (ALS)

- Laser scanning systems are active
  - They can work day and night
  - No problems in areas without texture (dark shadows)
- High vertical accuracy
- Density
- Automation
- Fast delivery time

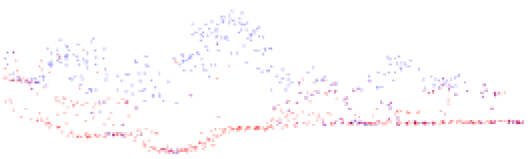


http://www.optech.ca/

ALS-Data …. Re-sampling

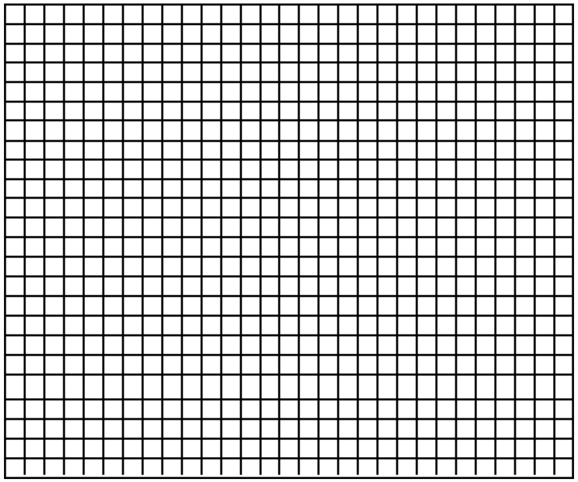
- Processing of irregularly distributed points as obtained from laser scanning takes more time than processing of regularly distributed ones.

•First received impulse
•Last received impulse



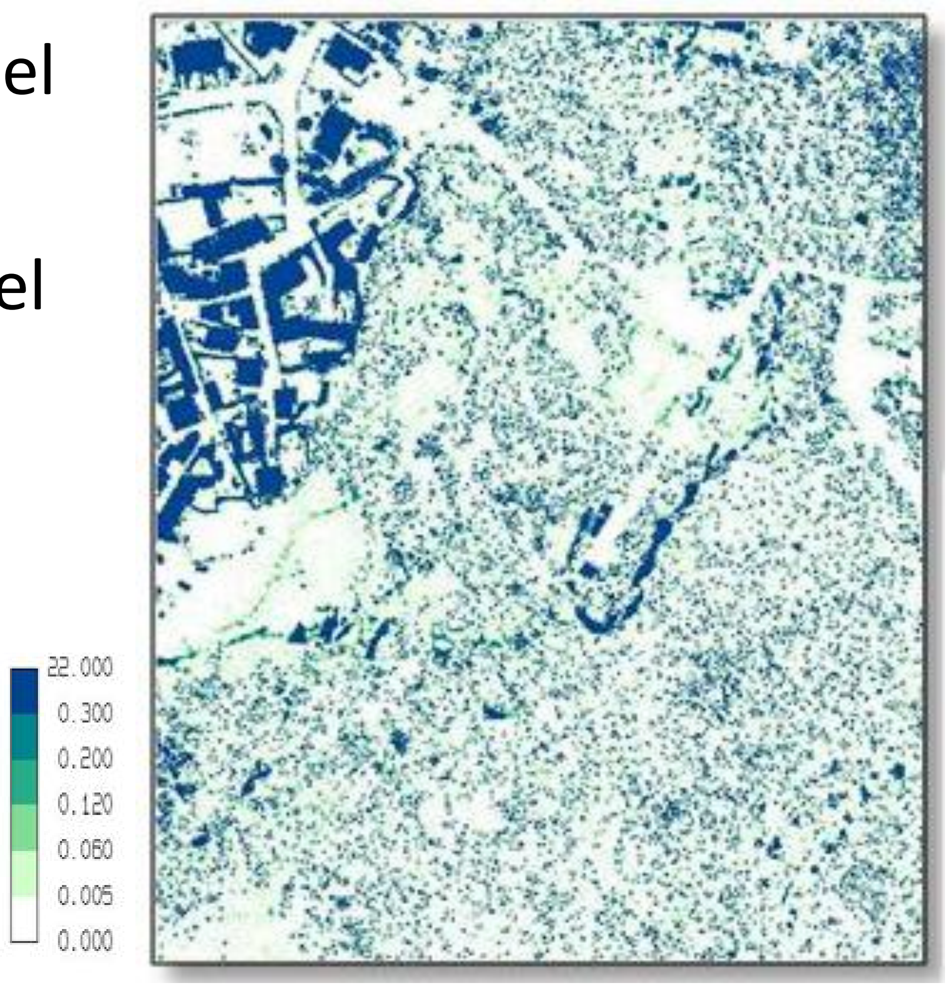
- Most procedures start by re-sampling the laser data into a regular raster.

(2D array of elevation values)



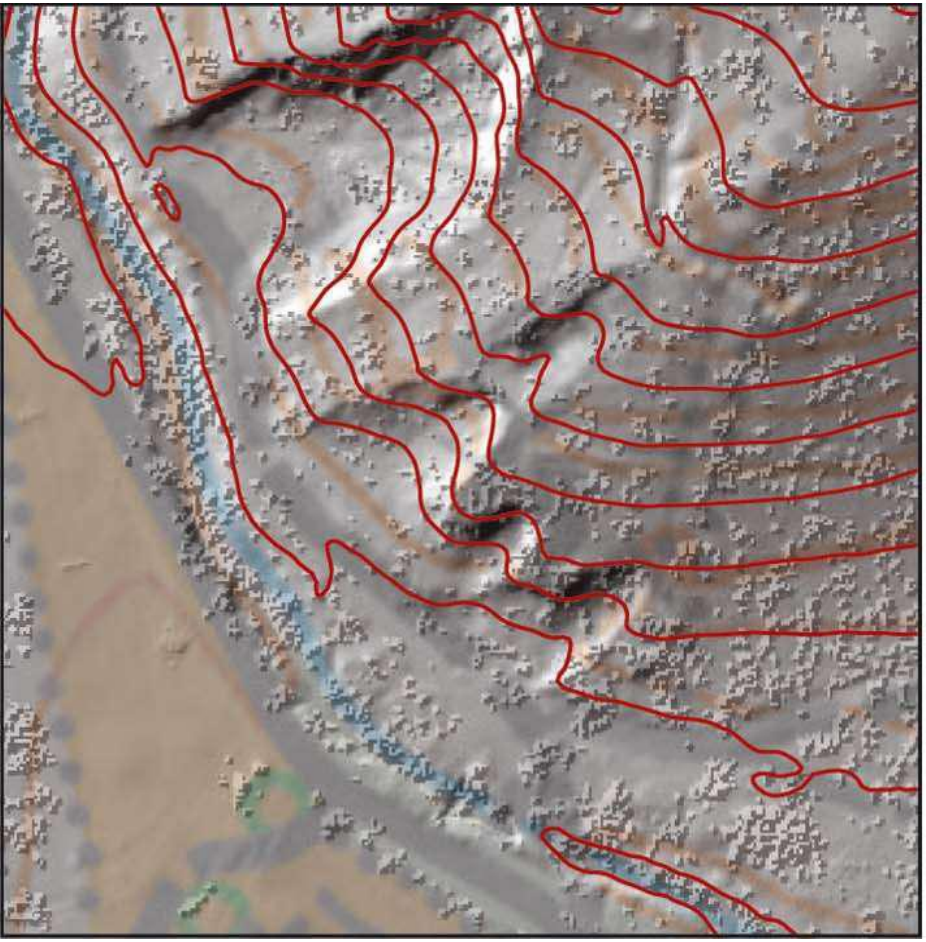
Topographic Modeling

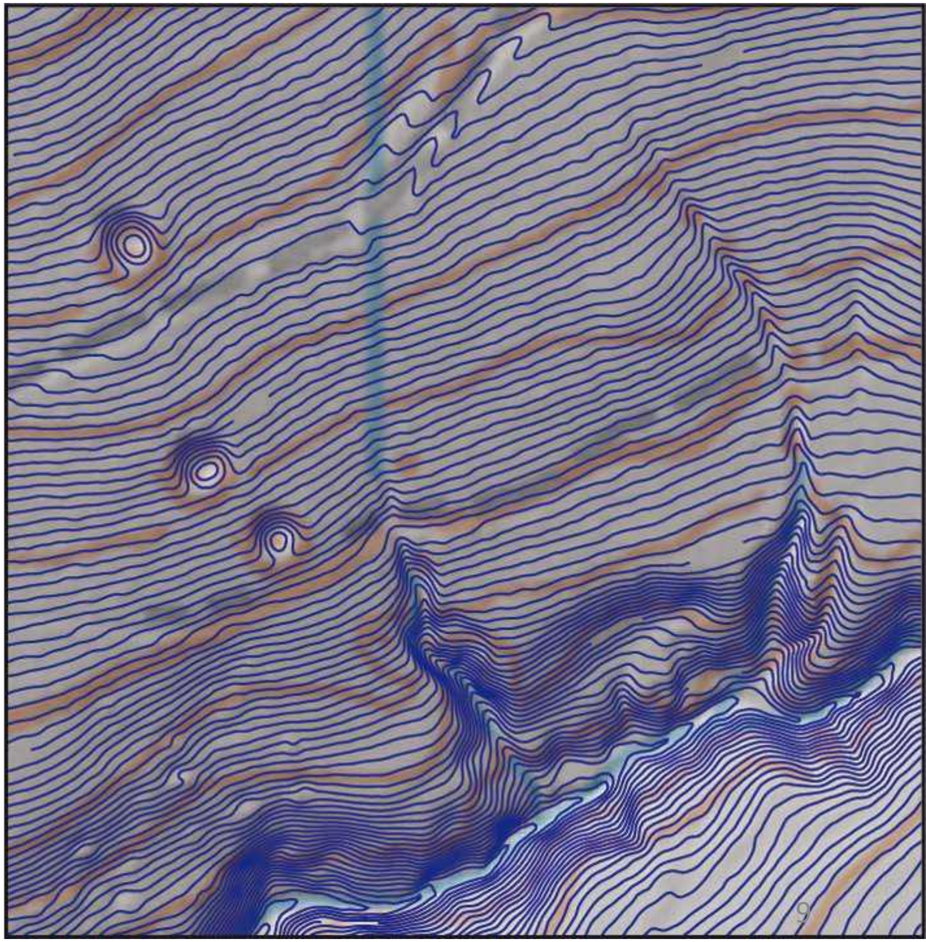
- DSM: Digital surface model
- DTM: Digital Terrain model
- nDSM: normalized digital surface model



Contour lines

- The primary format for representing elevation data



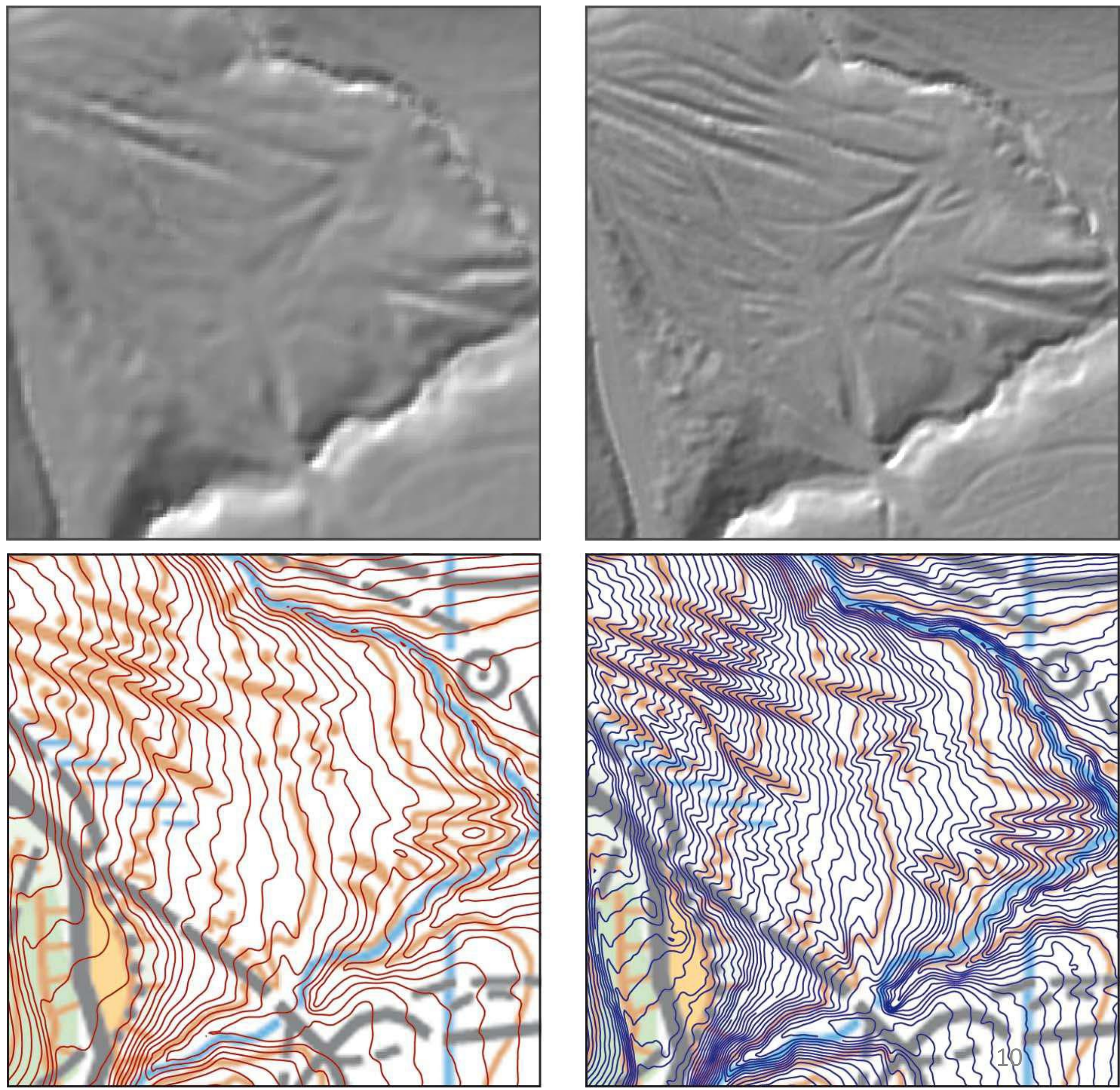


Depending on:

- DTM’s grid size (Re-sampling)

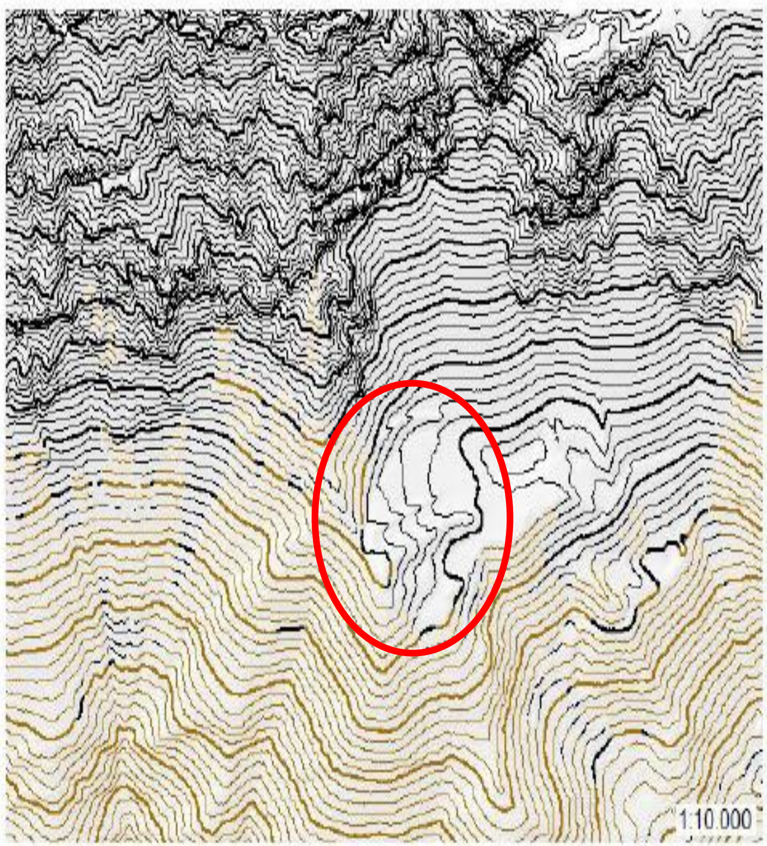
- DTM’s resolution (points density)

1 points/m² 4 points/m²

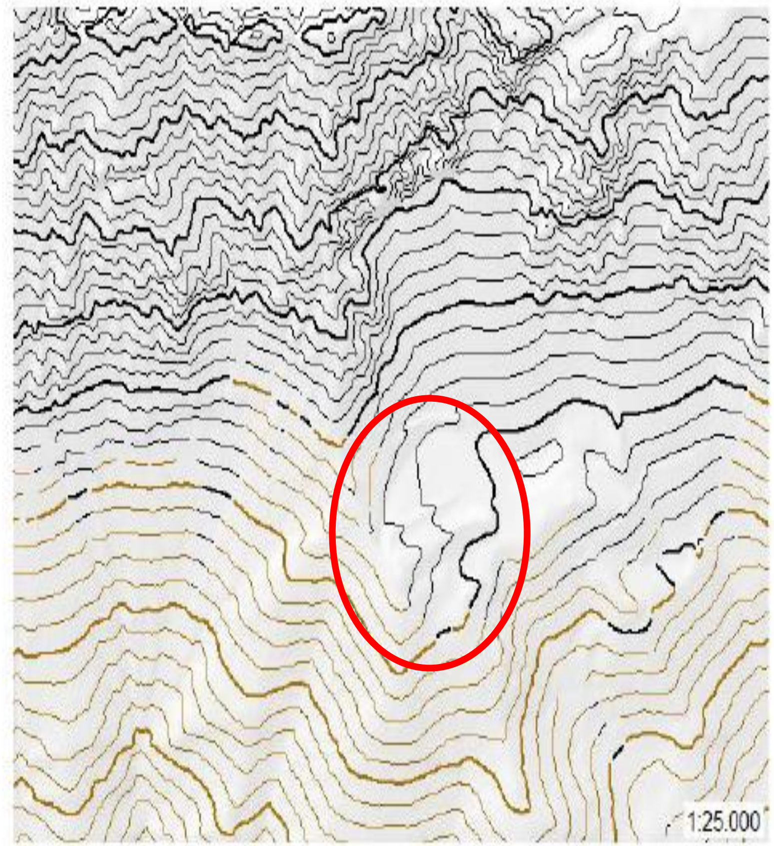


• Scale of the map

1:10000

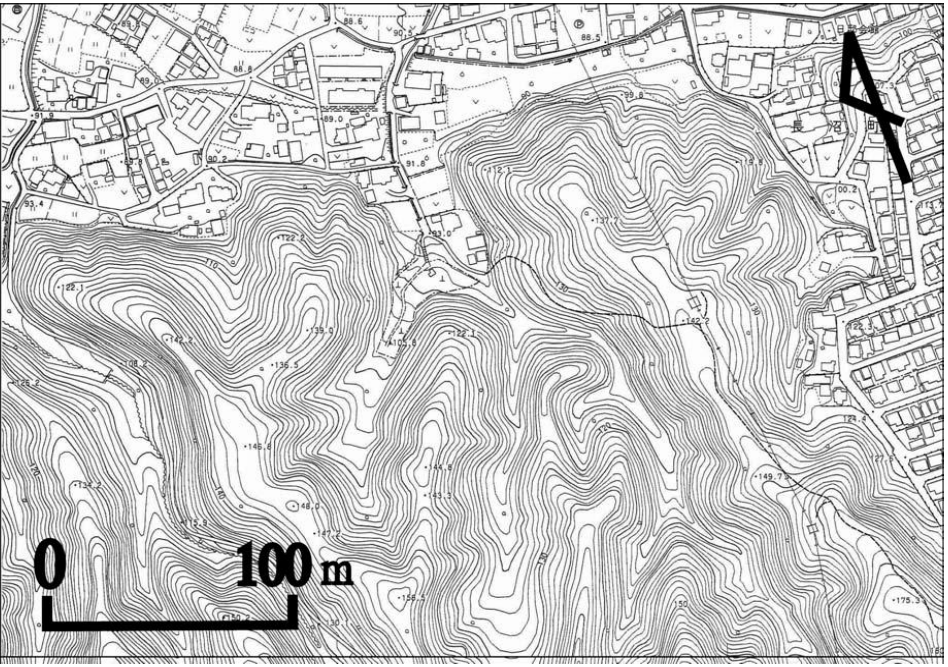


1:25000

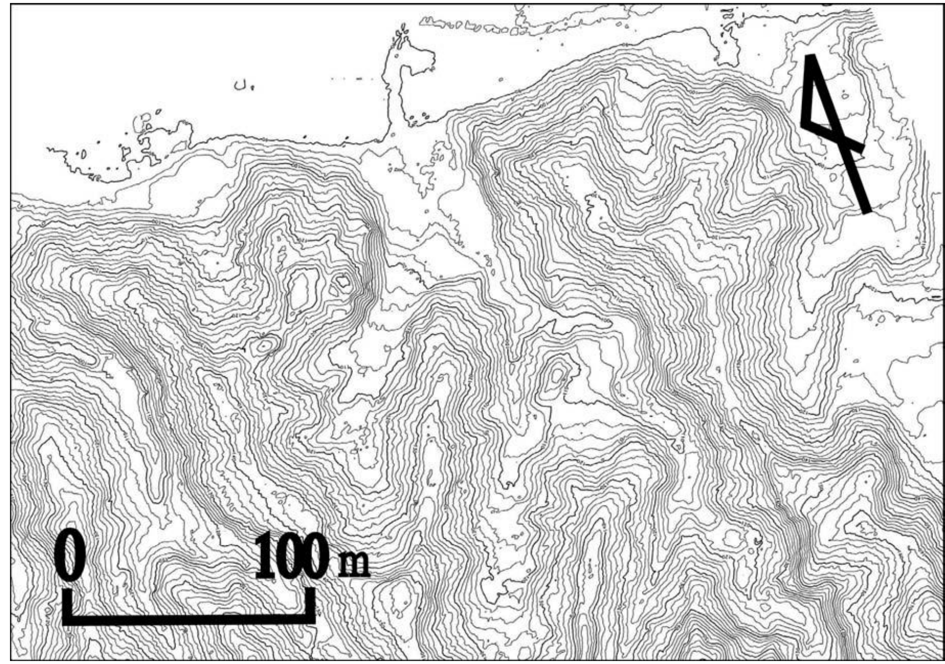


• Cartographic generalization will be needed to obtain smooth contour lines and optimal representation of the landscape

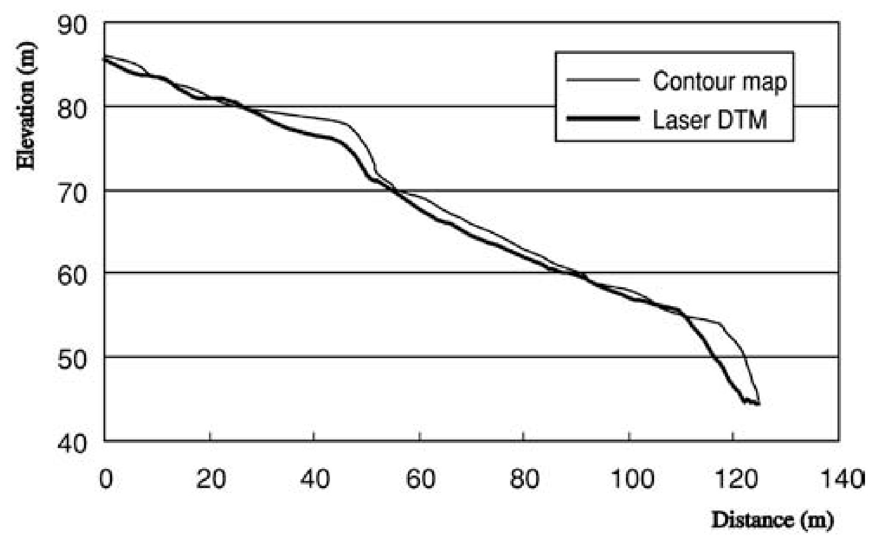
1: 2,500 photogrammetric contour map (Tokyo city planning map, 1999)



2 m interval contour map based on a 2 m grid DTM



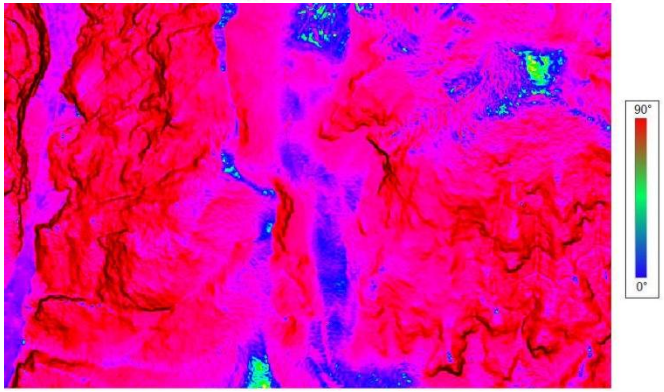
Overlap of cross sections based on a photogrammetric contour map and laser DTM



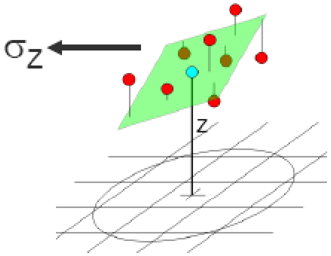
Topographic land-cover map

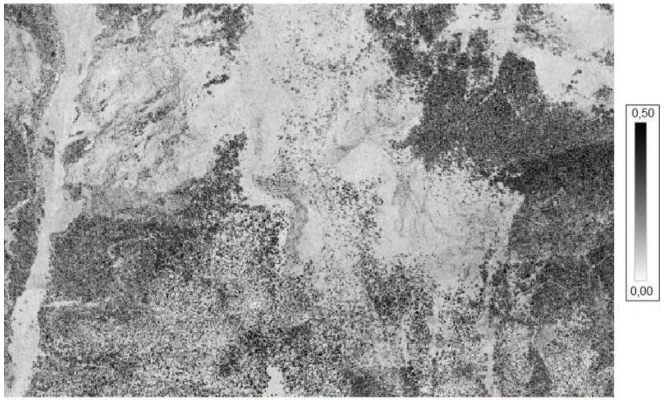
- Using ALS-data and additional data (Orthophoto) many attributes can be obtained to derive land-cover classes.

1. Terrain slope (Gradient):



2. Level deviation (Sigma):

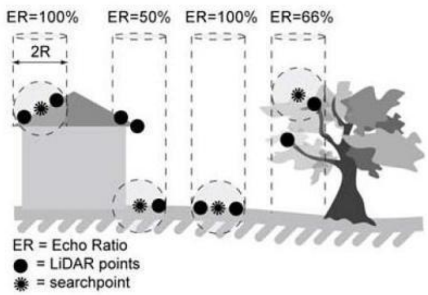


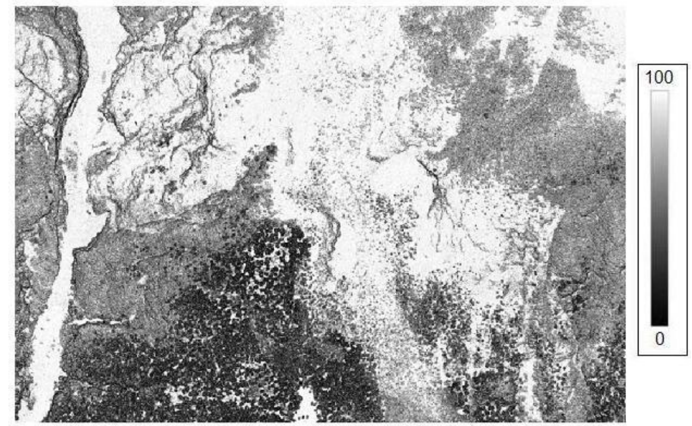


Topographic land-cover map

3. Echo-ratio:

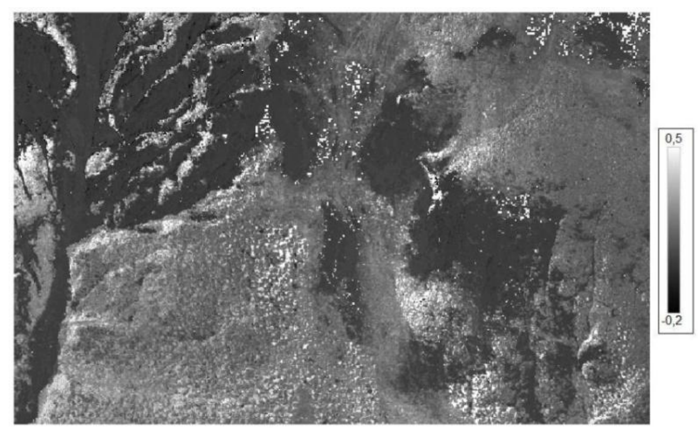
$$echo - ratio = \frac{n3D}{n2D} \times 100$$





4. Vegetation index (from orthophoto): VARI (*Visible Atmospherically Resistand Index)*

Or NDVI (normalized difference vegetation index)



5. nDSM

Topographic land-cover map - Classification

Derived attributes:

Terrain slope

Level deviation

Echo-ratio

nDSM

VARI/NDVI

Classification methods

Maximum –likelhood- method

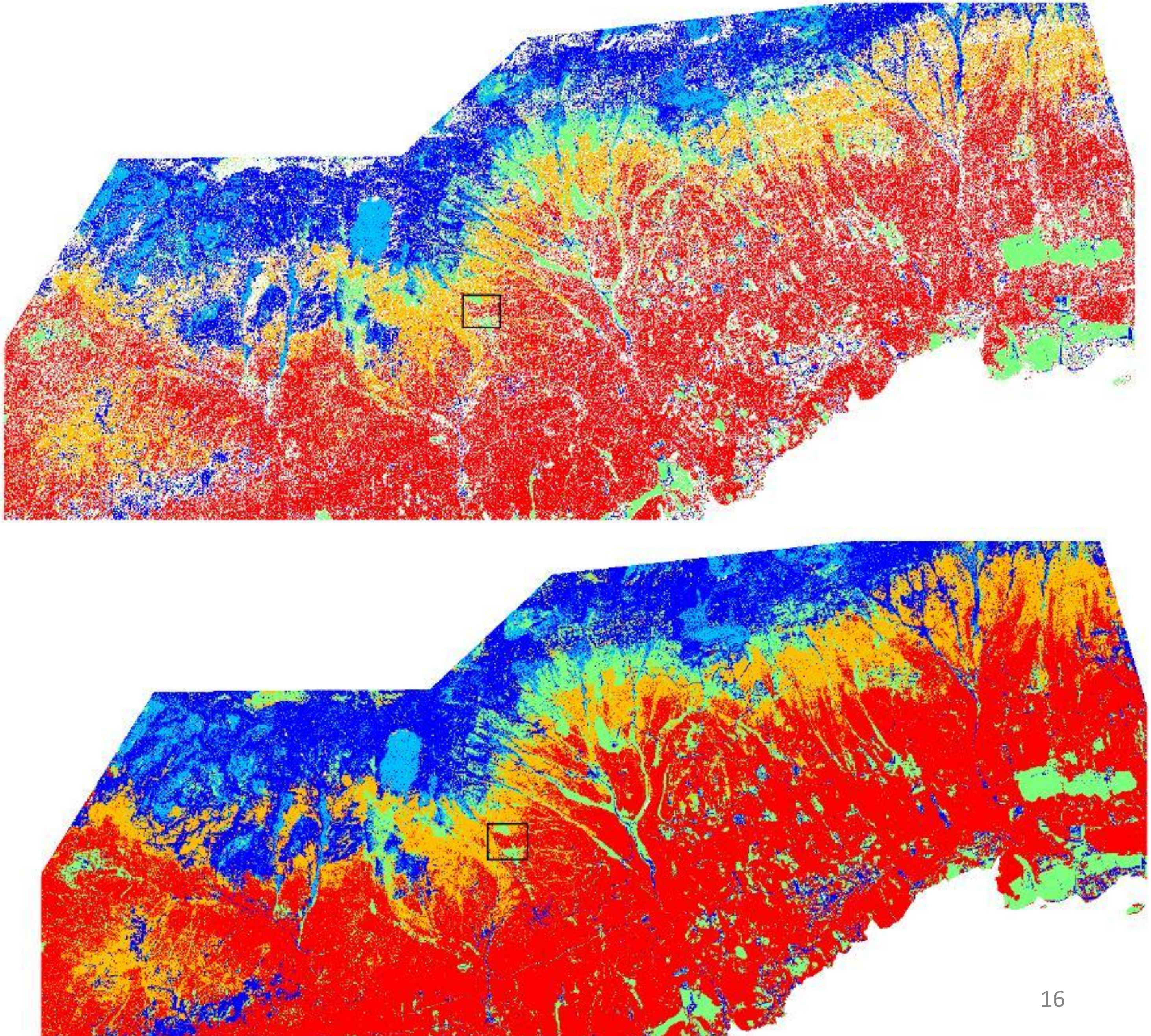
Supervised classification

Unsupervised classification

……………

e.g.

Class	Attribute	Conditions
Forest	Echo-ratio	<73.8%
	Sigma	<0.48m
	nDSM	>2.25m
	VARI	-0.009<VARI<0.408


Forest
Slouch
Meadow
Rock
Scree
Unclassified

Topographic land-cover map - Generalization

- Land cover map which is derived from ALS-Data and Orthophoto needs to be generalized by cartographers depending on the scale of the map

- In the case of classified land cover classes from ALS-data automated operation are used in generalization:
  - Digital image processing (neighborhood distance, edge detection, …)
  - Re-sampling
  - Vectorization (Raster to vector)
  - Reclassification (new classes)
  - Simplification (smoothing a line or area boundary)
  - Selection/Elimination

Topographic land-cover map - Generalization

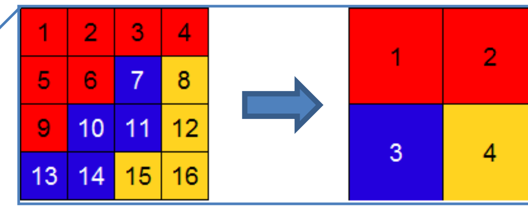
Workflow:

1.

- ALS-data/orthophoto
- Attributes
- classification
- Generalization
- Topographic land cover map

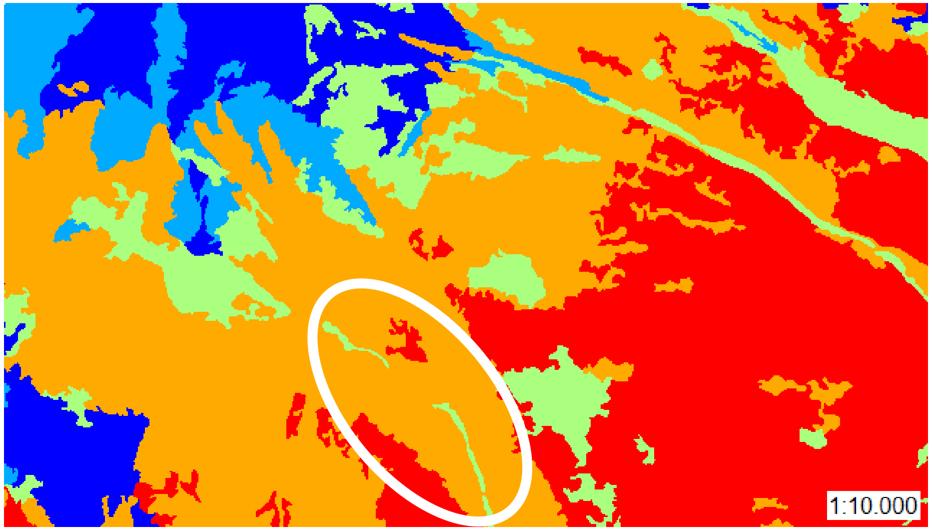
2.

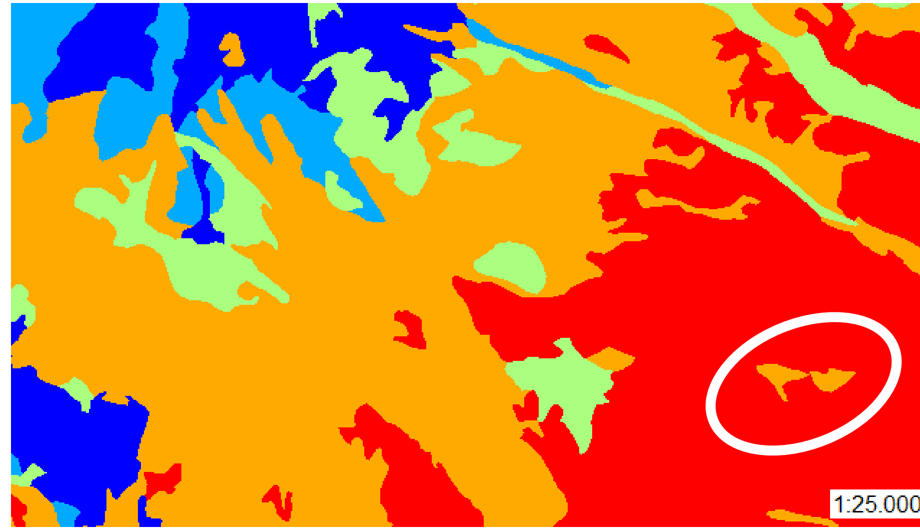
- ALS-data/orthophoto
- Attributes
- Generalization: Re-sampling
- Classification
- Generalization
- Topographic land cover map



Depending on the scale

First workflow:

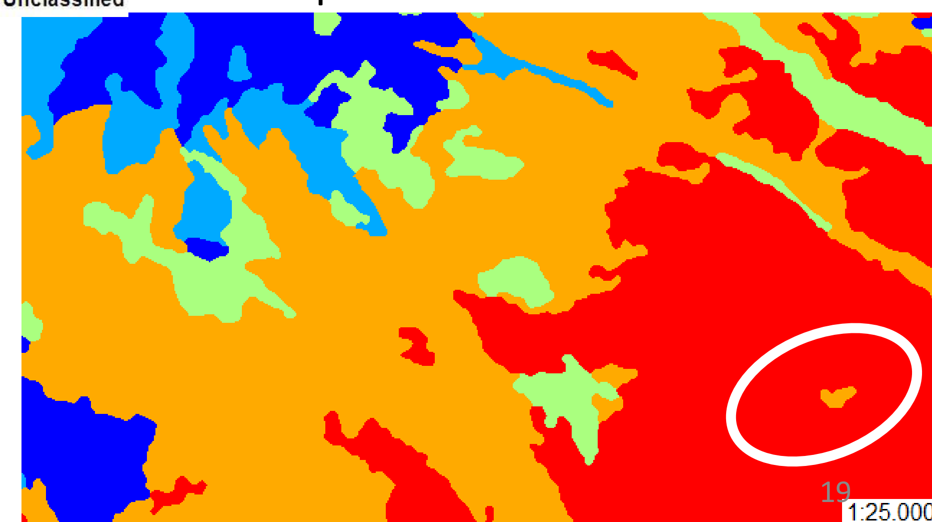


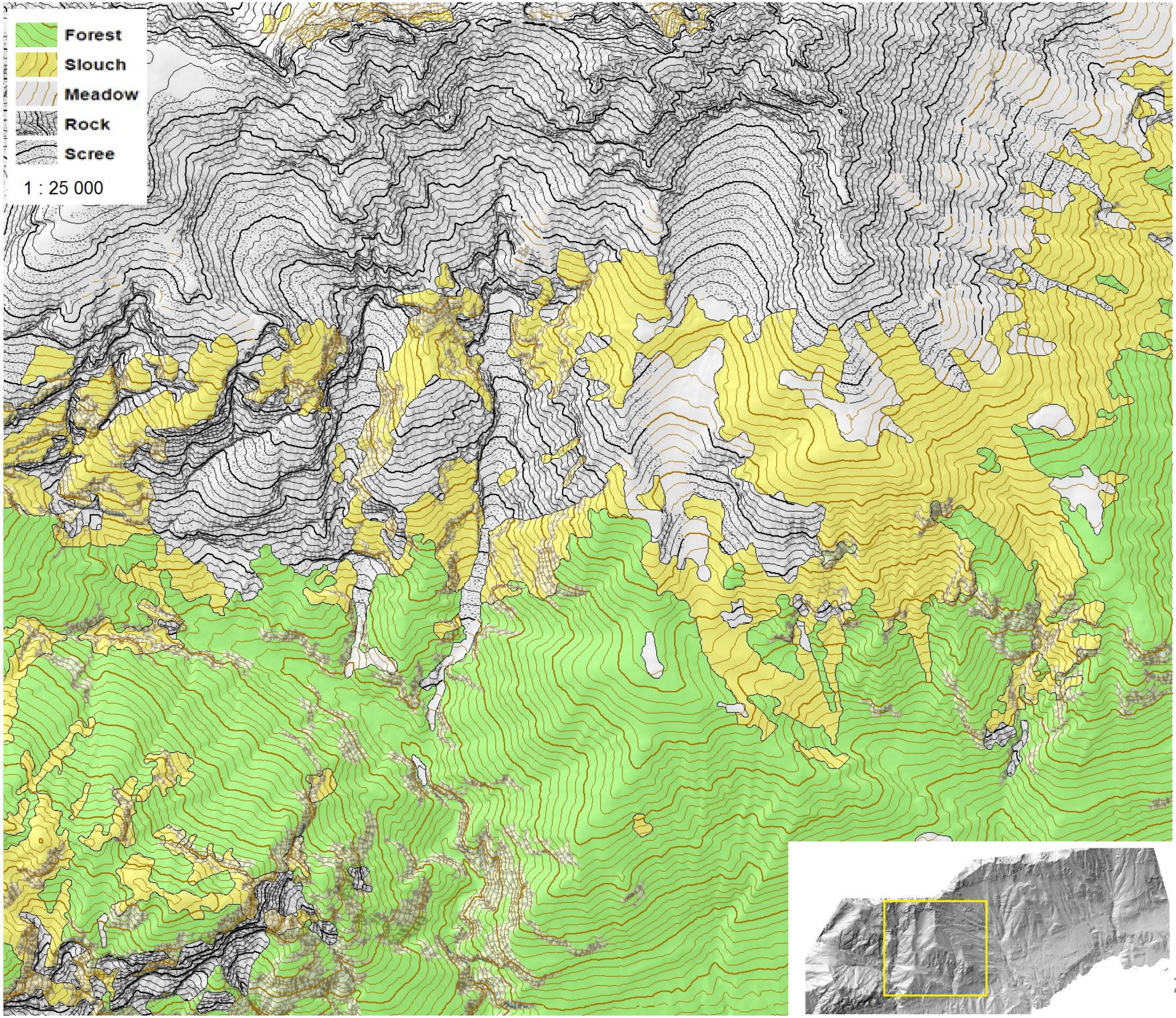


Second workflow:

Map 1:10.000: 1 m → 2 m

Map 1:25.000: 1 m → 5 m




Forest
Slouch
Meadow
Rock
Scree
1 : 25 000

Summary and further work

- Since the airborne laser scanner can measure the elevation under vegetation the topographic information is more detailed than the information obtained from maps drawn by another survey mapping specially in the fine topography of mountains regions.
- Quantitative estimation of topographical change by repeated measurement using an airborne laser scanner is possible.
- Integration between different topographic data acquisition technologies and develop new approaches to derive more precise topographic maps.

References

- Klauser, A. (2009): Automatisierte Ableitung einer topographische Bodenbedeckungskarte im subalpinen Bereich. Diplomarbeit, Institut für Photogrammetrie und Fernerkundung und Institut für Geoinformation und Kartographie der Technischen Universität Wien.
- Ortag, F. (2010): Map production. http://icaci.org/research-agenda/map-production. (accessed on 28.5.2010)
- Gartner, G. Ditz, R. Briese, C. Mücke, W. Pfeifer, N. (2007): Laser Scanning Data for Cartographic Data Modeling of Orienteering Maps. XXIII International Cartographic Conference, 4-10 August, Moscow 2007, Russia.
- Albertz,J. Wiedemann, A. (): Topographic and Thematic Mapping from Satellite Image Data. Department for Photogrammetry and Cartography, TU Berlin.
- Landtwing, S. (2005): Airborne Laser Scanning, Genauigkeitsinformationen für den Auswertungsprozess. Diplomarbeit, ETH Zürich, Schweiz.
- Kraus,K. (2000): Photogrammetrie, Topographische Informationssysteme. (Band3), Köln:Dümmler.
- Petzold,B. Reiss,P. Stössel, W. (1999): Laserscanning-Surveying and mapping agencies are using a new technique for the derivation of digital terrain models. ISPRS, Journal of Photogrammetry & Remote Sensing 54(1999) 95-104.
- Whitman, D. Zhang, K. Leatherman, P.S. And Robertson, W. (2003): Airborne Laser Topographic Mapping, Applications to Hurricane Storm Suge Hazards. Earth Science in the City: American Geophysical Union, (2003) P363-376.
- Carter, W. Shrestha, R. Tuell, G. Bloomquist, D. And Sartori, M. (2001): Airborne Laser Swath Mapping shines New Light on Earth's Topography. Eos, Transactions, American Geophysical Union, Vol.82, No. 46, Nov.13. 2001, P 549-555.
- Carpioli, M. (2000): Critical comparison between digital map and Laser Scanning.

  International Archives of Photogrammetry & Remote Sensing. Vol. XXXIII, Part B3. Amsterdam 2000.
- Oksanen, J. Sarjakoski, T. (): The EVRS and the need for contour updating in national topographic maps. Finish Geodetic Institute, Finland.
- Vosselman, G. Gorte, H. G. B. Sithole, G. : Change Detection for updating Medium Scale Maps Using Laser Altimetry. International Archives of Photogrammetry, Remote Sensing and Spatial Information Sceinces, Vol. 34, Part B3.
- Sato, P. H. Sekiguchi, T. : Mapping of Topography and Vegetation in Shirakami Mountains " World Heritage Natural Resources " in Japan. Geographical Survey Institute, Tsukuba, Japan.
- Sekiguchi, T. Sato, P. H. Ichikawa, S. And Kojiroi, R. (2003): Mapping of Micro Topography on Hill Slopes Using Airborne Laser Scanning. Bulletin of Geographical Survey Institute, Vol.49. March 2003, Japan.